Status on residual analysis of SHARAQ04 experiment

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Proton knockout reaction on radioactive fluorine and oxygen isotopes was performed in SHARAQ04 experiment at RIBF, RIKEN Nishina Center. The analyses on ^{14}O and ^{22}O have been reported by S. Kawase et al.[1, 2]. The identification of residual nuclei at downstream (S1 focal plane of the SHARAQ spectrometer[3]) serves an important role in identifying the reaction channel and separating the strengths in the excitation energy spectrum. The objective of the present analysis is particle identification via Z vs A/Q plot. We will explain the conversion from the energy loss (ΔE) vs time-of-flight (TOF) plot to the Z vs A/Q plot.

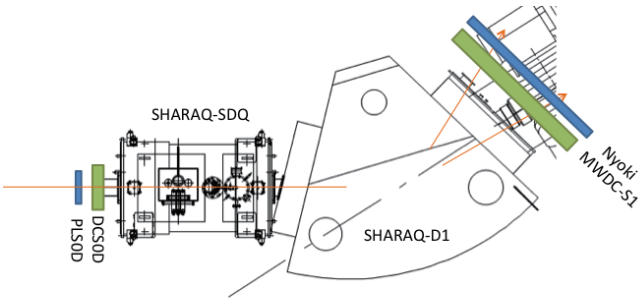

Fig. 1. Experimental setup before S1 focal plane of SHARAQ spectrometer.

Figure 1 shows the experimental setup for downstream. The TOF was measured by an array of 14 identical plastic scintillators (5 mm X 50 mm X 85 mm), named Nyoki, with a plastic scintillator (PLS0D) located in the entrance of the SDQ magnet as start timing. Each scintillator of Nyoki was labeled from 0 to 13. The even ID scintillators were 10 mm downstream from odd ID. There was 5 mm overlap between adjacent IDs. The energy loss of each Nyoki's scintillator was calibrated with the energy loss in PLS0D. The positions of the residual nuclei were measured by an MWDC at the exit of the D1 magnet. The flight-length was then calculated by using the position at S1. The velocities of the residual nuclei were calculated from the flight length and the TOF.

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The conversion from ΔE-TOF to Z-A/Q is based on the following equations,

$$Z = \beta \sqrt{\frac{L}{g + h\,L}}, \tag{1}$$

$$\frac{A}{Q} = \left(\frac{c}{u}\right)\frac{1}{\gamma\beta}\left(B_\rho\right)_{D1}\left(1 + \frac{x}{(x|\delta)}\right), \tag{2}$$

where β and γ are the Lorentz factors of residual nuclei; L is the light output of Nyoki; g and h are the parameters from the Birks formula[4], which correct the non-linearity of light-output and energy loss; c is the speed of light in vacuum; u is the atomic mass unit; $(B_\rho)_{D1}$ is the magnetic rigidity of the D1 magnet (6.5269 Tm); x is the x-position on MWDC-S1; and $(x|\delta)$ is the dispersion at the S1 focal plane.

Figure 2 shows the Z vs A/Q plots for the beam without reaction. The left plot is from downstream and the right plot is from upstream. The accuracy and resolution of both Z and A/Q in the downstream plot are bad compared with those in the upstream plot. The resolution of Z is 0.3 in the downstream plot, while it is 0.1 for the upstream plot. The resolution of A/Q is 0.1 for the downstream plot, and it is 0.01 for the upstream plot.

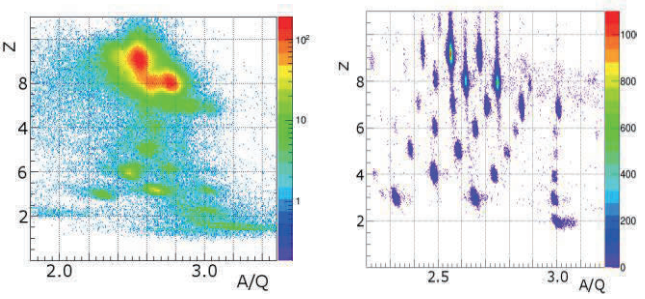

Fig. 2. Z vs A/Q plots under beam trigger; (left) downstream; (right) upstream.

The analysis is still in progress. We are focusing on improving the accuracy and resolution by 1) better estimation of the parameters such as g, h, and $(x|\delta)$; 2) better calculation on flight-length; and 3) better tracking of SMWDC-S1.

References

1) S. Kawase *et al.*: RIKEN Accel. Prog. Rep. 46 (2013) 30.
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4) W. R. Leo: Techniques for Nuclear and Particle Physics Experiments (Springer-Verlag, Berlin, 1994), P 168.